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CWL TECHNICAL MEMORANDUM 33-18

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INTERIM REPORT

CWL TRAVERSAL PROGRAM PHASE A - PERSISTENCE

9 February 1959

by
Norman Reich

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Directorate of Development
U.S. Army Chemical Warfare Laboratories
Army Chemical Center, Maryland

CONFIDENTIAL

CWL Technical Memorandum 33-18
Status Report
CWL Traversal Program
Phase A - Persistence

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ABSTRACT

(U) Object.

The object of this phase of the Traversal Program is to study the persistence of V-agent in various types of terrain.

(C) Results.

Twenty-three soil plots were contaminated with agent dispersed in densities ranging from 0.3 to 31.5 g/sq m and in particles having mass median diameters from less than 200 to 4,100 microns. The quantity of agent in the top 1/2-in. layer of soil, as determined by chemical analysis of soil plugs, was found to fluctuate considerably, and therefore no well defined relationship between residual contamination and time could be established. However, the fitted decay curves indicated a rapid decline in residual contamination followed by a leveling off at very minute concentrations. The individual effects of specific parameters were not easily discernable from the data; however, evidence existed to indicate that meteorological conditions had some effect on persistence (ie, high temperature and rainfall reduce persistence). More than 80% of all clipped rabbits died when exposed to contaminated surfaces within an hour after the soil was contaminated. The number of kills dropped to below 20% when the exposure was one day following the dissemination of agent.

Eight sand plots were contaminated with agent dispersed in densities of approximately 6.5 to 20 g/sq m and in particles with mass median diameters ranging from about 200 to 3,600 microns. All animals exposed to these plots one and 24 hours following the dissemination of agent were killed; exposure after one week resulted in no deaths even though the presence of residual agent was detectable by chemical analysis of 1/2-in. deep sand plugs. The curves of residual contamination density vs time for both soil and sand were of the same shape, and differences in rates of decline were attributable to the differences in the physical characteristics of the two media.

Nine plots of grass sod with dense vegetation about three inches tall were contaminated to densities 0.3 to 17 g/sq m with agent dispersed in particles ranging from about 200 to 500 microns. The results of animal exposure indicated V-agent was less persistent on both grassy terrain and soil than on sand.

Since the residual contamination as detected in the top 1/2-in. layer of terrain did not agree with the results of animal exposure, a blotting-type surface sampler was developed to measure the quantity of transferable agent on the surface. Its employment in a series of supplementary trials indicated that the contamination on the surface declined much more rapidly and was more adversely affected by weather than was the contamination in the 1/2-in. layer of terrain. Whereas VX in terrain was chemically detectable for weeks after the dissemination of agent, the surface contamination persisted only a few days.

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INTERIM REPORT

CWL TRAVERSAL PROGRAM
PHASE A - PERSISTENCE

I. (U) INTRODUCTION.

A. Object.

The object of this phase of the Traversal Program is to study the persistence of V-agent in various types of terrain.

B. Authority.

This investigation was authorized in the Chemical Warfare Laboratories Traversal Program, dated 25 March 1957.

II. (C) BACKGROUND.

The Traversal Program, implemented by direction of the Deputy Commander for Scientific Activities, U.S. Army Chemical Warfare Laboratories, is detailed in a CWL document, subject: The Casualty Producing Capability of V-agent when Dispersed as Terrain Contaminant (C), dated 25 March 1957. This program, whose primary objective is to estimate potential casualties arising from traversal and occupational hazards, is divided into the following three phases:

Phase A - Persistence and Decontamination - Determining the persistence of V-agents in the field and factors governing this persistence.

Phase B - Pick-Up - Determining the degree of pick-up by personnel traversing or occupying areas on which V-agent is dispersed as a terrain contaminant. AD-304 772

Phase C - Casualty Production - Estimating the effectiveness of this pick-up in producing casualties.

Although portions of all three phases were and are currently being conducted simultaneously, this report deals solely with that subdivision of Phase A concerned with investigating the persistence of (VX). In subsequent reports, the results of other trials conducted under the scope of the Traversal Program will be covered.

Experiments to investigate the persistence of VX on soil, sand, and vegetated terrain as a function of general terrain characteristics, and the contamination density and particle size of the dispersed agent were initiated in March 1957. The data accumulated since that date, including some previously reported information *, are presented here. These results and the inferences drawn therefrom are regarded as interim in nature, and as such are issued for temporary or limited use only. They may be superseded when additional data are received and evaluated.

* CWL Technical Memorandum 33-9, subject: The Casualty Producing Capability of V-Agent When Dispersed as Terrain Contaminant (C), Interim Report, Phase A - Persistence; A. Koblin, W.C. Johnson, and A. Deiner; dated 9 October 1957.

III. (C) EXPERIMENTAL.

A. Procedure.

Trials investigating the persistence of VX in soil, sand, and vegetated terrain were conducted generally in accordance with Test Plan No. 23, which appears as appendix B to the CWL Traversal Program, dated 25 March 1957. As provided for in the test plan, agent was uniformly dispersed in various contamination densities and particle sizes on prepared test plots, and at prescribed intervals these areas were checked for the presence of residual agent by chemical sampling and animal exposure. Throughout the test period a detailed record of prevailing meteorological conditions was maintained.

B. Preparation of Test Sites.

1. Soil.

An area on Carroll Island was enclosed by a barbed-wire fence and cleared of vegetation and extraneous matter. The soil in this area, which is described in appendix D, was disked, leveled, and permitted to settle or pack-down naturally for about one month before the site was subdivided into a number of 1 x 10 ft test plots. Each test plot was defined by a wooden frame as shown in figure 1, appendix C. Tarpaulin covers supported on frames were provided to protect some plots from direct solar radiation and rainfall. These covers were raised above the ground to permit the passage of air over the test surfaces, and were pitched to allow rain to run off into drainage ditches dug between adjacent plots.

2. Sand.

In the general vicinity of the soil plots, beach sand transported from the shoreline of Carroll Island was deposited in a layer one-foot thick. In a manner as that described in par 1, above, the sand-covered area was subdivided into test plots.

3. Sodded Terrain.

Commercial lawn sod was laid in an area adjacent to the soil and sand plots. When the sod had taken root, the area was sectioned off into 3 x 10 ft test plots. Prior to contamination, the test site was periodically mowed to keep the dense grass to a height of about 3 in.

C. Agent-Dissemination Techniques.

Agent was applied to the surfaces of test plots in desired contamination densities and particle sizes by employment of either the macroburette, the microburette, or the spinning-tip apparatus. The macroburette producing "large" droplets (about 3,500 microns) and the microburette producing "medium" droplets

(ranging from about 800 to 1,500 microns) were operated in a similar manner. The burettes were filled with a specific quantity of agent which the operator manually and visually attempted to distribute uniformly over the test plot. The spinning-tip was employed in generating "small" droplets with mass median diameters ranging from below 200 microns to about 800 microns. This apparatus, which is described in detail in CRLR 375*, is shown in fig 2, appendix C. The unit was mounted on a sled and was drawn back and forth along the longitudinal axis of the test plot as agent was forced out through the tip by centrifugal action. The desired contamination density and particle size distribution were attained by selecting the appropriate tip orifice and by controlling the rates of revolution and traversal.

D. Sampling Techniques.

1. Ground-Deposition Sampling.

a. When burettes were employed to disperse agent, the exact quantity of agent deposited on the ground was known or could be easily acertained from the calibrations on the burettes. Therefore, no field sampling was required for measuring contamination densities. The average particle sizes of the dispersed agent was determined from the mass and/or volume of a number of captured droplets.

b. When the spinning-tip apparatus was employed, petri dishes containing solvent (hexylene glycol) and coated microscope slides were placed in the field. From the agent deposited in the petri dishes, as determined by DB-3 analysis of the solvent, the degree and uniformity of ground contamination was ascertained. Particle size distribution was obtained by measuring the spots on the coated slides with the aid of a microscope.

2. "Soil-Plug" Sampling.

Within an hour after contamination and at prescribed intervals thereafter, the quantity of residual agent in the top 1/2-in. layer of soil and sand was determined. This was accomplished by removing plugs or cores of earth from the contaminated test plots, extracting these plugs with solvent (isopropyl alcohol), and analyzing the extract for active agent by the DB-3 technique. (The dimensions of the plugs were fixed to permit the analytical results to be given in mass per unit area.)

3. Surface Sampling.

To estimate the quantity of agent transferable from the surface, as opposed to the quantity of agent in the 1/2-in. layer, a blotting-type sampler was employed as a substitute for or in conjunction with the "soil-plug" sampler. Absorbent cotton covered with cheese-cloth with a contact area of 8 sq in. was pressed against the contaminated surface at a pressure of 5 lb/sq in. for 1 hr. The contaminated pad was then extracted with solvent (isopropyl alcohol) and the extract was analyzed by the DB-3 method.

*CRLR375, subject: An apparatus for the Production of Uniform Droplets (Spinning Tip), A. Koblin, dated 20 September 1954. AD-46673

4. Animal Sampling.

At prescribed intervals after the dispersion of agent, rabbits with their abdominal fur clipped were exposed for one hour to the contaminated surfaces of test plots. Since only percutaneous effects were sought, the animals were restrained and otherwise prevented from receiving doses of agent through other channels such as by oral ingestion. During these exposures, approximately 50 sq cm of fur-free skin per kg of the rabbits' mass were in direct contact with contaminated surfaces. The quantity of transferable contaminant on test surfaces was indicated by the lethal effects and cholinesterase depressions suffered by exposed animals. Also, the indicated doses of agent received by rabbits were calculated from time till death and fractional mortality of groups of exposed animals.

E. Test Results.

1. Soil.

During the period of March through August 1957, 23 soil plots were contaminated with VX in densities ranging from 0.3 to 31.5 g/sq m and particles having mass median diameters of about 200 to 4,100 microns. The specific conditions for individual trials, as well as test results, are presented in table 1, appendix A. These results are graphically depicted in figures 1 and 2, appendix B.

The chemical data (ie, the residual contamination densities as determined from soil plugs) show considerable fluctuation. As a result of these variations, trends and inferences, rather than clearly defined relationships, could be derived from these data. Also, because of these deviations and the inability to control the variables adequately in the field for extended periods of time (particularly meteorological conditions), assessment of specific effects of individual parameters on persistence was difficult. However, to aid in identifying the trends and estimating the effects of parameters, curves were drawn to show the relationship between contamination density and time. The general shape of the curves indicated that the decline in residual contamination was initially very rapid and leveled off almost asymptotically with respect to time at minute concentrations; traces of VX were found several weeks after the agent was dispersed. The initial rate of decline seemed directly proportional to the density of the dispersed agent. Thus, regardless of the quantity of agent dispersed, several days after dispersion the residual contamination became essentially equal and ineffective. The rate of contamination decline was also found to be affected by meteorological conditions; that is, high temperatures and rainfall appeared to reduce persistence. All these effects seemed to be independent of particle size.

The animals exposed to contaminated test plots were essentially sampling tools to indicate the presence of VX available for transfer from the surfaces. From deaths and/or depressions in cholinesterase levels of rabbits exposed in these trials, it was learned that the surface contamination disappeared within a matter of days. When agent was disseminated in densities below

7 g/sq m, few fatalities were suffered by animals exposed for one hour at 24 hours after the plot was contaminated (cf, table 4, appendix A). For higher contaminations, deaths might be expected to occur upon exposure several days after the dissemination of agent.

A comparison of chemical and animal data obtained during these trials was made. Since the results, as presented in the following table, indicate that the quantity of agent in the top 1/2-in. layer of soil cannot be directly correlated to animal kills, and hence, does not reflect the amount of agent available for transfer, a new blotting-type sampler (cf, par C, 3) was devised and employed to sample agent on the surface of terrain contaminated by the detonation of candidate VX-filled munitions. The results of these supplementary trials (cf par IV) reveal that surface contamination declines much more rapidly and is more adversely affected by weather than is the contamination in the top 1/2-in. layer of soil. This condition tends to explain the fact that animal kills appear more closely related to time than to the quantity of active agent extractable from soil plugs.

Rabbits Killed on 1-Hr Exposure to Contaminated Soil

Residual contamination density*	Time After Initial Contamination					
	1 Hour		1 Day		1 Week	
g/sq m	Dead/Exposed	%	Dead/Exposed	%	Dead/Exposed	%
≤ 1.0	10/18	55	2/18	11	5/28**	18
1.1 - 2.0	5/6	83	0/4	0	0/4	0
2.1 - 3.0	2/2	100	3/8	38	1/2	50
3.1 - 4.0	6/6	100	2/8	25		
4.1 - 5.0	2/2	100			1/2	50
5.1 - 6.0	2/2	100				
6.1 - 7.0	2/2	100				
> 7.0	6/6	100	1/6	17		
Total	35/44	80	8/44	18	7/36	19

REMARKS:

*Residual contamination density was determined by DB3 analysis of soil plugs taken at the time of animal exposure.

**The five deaths resulted from exposure of rabbits when the ground temperature was 99°F. Other inconsistencies in the data are also attributed to excessively high or low ground temperatures.

2. Sand.

During the period of August through October 1957, sand plots were contaminated with agent disseminated in densities of approximately 6.5 to 20 g/sq m and particle sizes ranging in mass median diameters of about 200 to 3,600 microns. The specific conditions for individual trials and test results are presented in table 2, appendix A. These results are graphically depicted in figure 3, appendix B.

All animals exposed for one hour to these plots one and 24 hours after the initial dissemination of agent died. Exposure after one week resulted in no deaths even though the presence of residual agent was detected by chemical analysis of 1/2-inch deep sand plugs. Since curves of residual contamination vs time for both soil and sand are of the same shape, and since differences in the persistency of VX in these media can be attributed to soil physics (ie, the differences in the general characteristics of soil and sand), further testing in sand was suspended after the conduct of eight trials.

3. Sodded Terrain.

The general conditions of the trials involving the contamination of sodded terrain and the results obtained from these trials are presented in table 3, appendix A.

Three trials were conducted in January 1958, and six were conducted in June and July of the same year. The contamination densities and particle size distributions employed were 0.3 to 17.2 g/sq m with mass median diameters of 185 to 450 microns, respectively. Since, in a general manner, these nine trials indicated that the persistency of VX in soil, sand and sodded terrain is roughly of the same magnitude, further testing on sodded terrain was discontinued.

In the January trials, the residual contamination was obtained by adding the quantity of agent on grass (as determined by DB3 analysis of solvent washings of grass clipped from 6 x 6-in. areas of the test plot) to that found in the 1/2-in. layer of soil beneath the grass. In the later trials, the contamination was obtained by employing the DB3 technique to determine the quantity of agent picked up by blotting-type surfaces samplers. Both techniques indicated that the rate of fall off or deterioration of ground contamination was initially quite rapid. Also, despite the differences in sampling technique, the inverse relationship between persistence and temperature can be inferred from the chemical data. This inference might also be drawn from animal data which proved somewhat erratic due to both the extremely low and high ground temperatures during the test periods.

IV. (C) SUPPLEMENTARY TRIALS.

During the conduct of the following field trials which were not primarily concerned with Phase A of the Traversal Program, VX-contaminated terrain was periodically sampled to provide data to supplement the results presented in par III, above, derived through the execution of Test Plan No. 23.

A. Field Test No. 1979.

On 5 March 1958 a VX-filled E5 land mine was detonated on the agent test site on Carroll Island. One hour after burst and daily thereafter, soil plugs and surface samples were taken from an area near the burst point where gross contamination resulted. All samples were analyzed for the presence of agent by both the DB3 and total phosphorus techniques. The resulting data tabulated below revealed that the contamination on the surface not only declines more rapidly, but is also more adversely affected by rainfall than is the contamination in the top 1/2-in. layer of soil. Also, the declining DB3 to total-phosphorus ratio in the surface samples is indicative of the possible degradation of VX on the surface of the terrain.

Residual Contamination at Various Times After the Detonation of an E5 Land Mine (FT 1979)

Date sampled	Residual contamination				Remarks
	Soil samples		Surface samples		
	DB3	Phos	DB3	Phos	
	g/sq m	g/sq m	g/sq m	g/sq m	
5 Mar 58*	10.2	10.6	15.4	18.2	
6 Mar 58	8.5	8.5	10.7	12.6	
7 Mar 58	0.8	2.7	1.0	1.1	Av air temperature during test period was 36°F. Approximately 1.0 in. of rain fell between 13 and 17 March.
10 Mar 58	10.7	10.3	1.7	2.2	
11 Mar 58	8.1	8.3	1.7	2.6	
12 Mar 58	6.6	6.7	1.6	2.5	
13 Mar 58	6.8	9.8	2.5	4.5	
17 Mar 58	5.7	6.5	0.14	0.31	

*One hour following burst.

B. Field Test No. 1976.

On 23 April 1958 a VX-filled E130 bomblet was statically fired 10 ft above ground on the test site described in par A, above. The ground contamination was low, and soil and surface sampling extended over a three-day period. The indicated rate of the decay in contamination is represented by the following residual contamination densities as determined by DB3 analyses of samples taken one hour, one day, and two days after burst, respectively: From 1/2-in. deep soil plugs, 294, 50, and 42 mg/sq m; and from surface samples, 89, 39, and 7 mg/sq m. (Note: 0.22 in. of rain fell between the second and third sampling periods.)

C. Field Test No. 1980.

On 17 July 1958 a VX-filled E5 land mine was detonated on the Carroll Island test site. The terrain was wet during the conduct of the test, and heavy dew and intermittent showers were experienced during the sampling period. Soil and surface samples were taken from an area whose initial contamination density, as determined from ground deposition plots, was about 750 mg/sq m. The indicated rate of decay in contamination is represented by the following residual contamination densities as determined by DB3 analysis of samples taken one hour, one day, and four days after burst, respectively: From 1/2-in. deep soil plugs, 140, 25 and 10 mg/sq m; and for surface samples, 155, 25 and 0 mg/sq m.

D. Test Plan No. 29.

In trials primarily designed to establish the relative transferability of agent and simulant from the ground to clothing, a test site on Graces Quarters with a moderately dense coverage of grass about 3 inches tall was uniformly contaminated with VX in densities ranging from about 1 to 14 g/sq m. On 30 July 1958 the agent was dispersed from the multijet disperser as shattered droplets (about 500 microns); and on 12 August as free falling droplets (about 3,000 microns). Within an hour after the dispersion of agent, blotting-type surface samples were taken from each test area. On the following two days, the presence of residual toxic agent was determined by surface samplers and exposed rabbits. The persistency of active agent on grass-covered terrain during warm, moderately-wet weather is indicated in the following table:

Residual Contamination and Fractional Mortality at Various Times After Dissemination of VX on Grass-Covered Terrain

Trial no.	Initial contamination density	Particle size	Residual surface contamination			Rabbit mortality		
			1 Hour	1 Day	2 Days	1 Hour	1 Day	2 Days
	g/sq m		mg/sq m			(Deaths/Exposures)		
1	8.5	Small	1,950	111	7	—	—	0/2
2	13.9	Small	2,690	128	8	—	1/2	0/2
3	6.9	Small	1,300	52	4	—	0/2	—
4	3.6	Small	890	35	3	—	0/2	—
5	2.2	Small	230	—	1	—	0/2	—
6	10.0	Large	1,700	80	0	—	0/2	—
7	12.9	Large	2,900	116	0	—	0/2	—
8	8.2	Large	980	54	0	—	0/2	—
9	3.4	Large	1,380	10	0	—	0/2	—
10	1.0	Large	50	0	0	—	—	—

Remarks:

Trials 1 through 5: Average air temp 80°F, 0.26 in. rain between 1-hr and 1-da sampling; trace of ppt between 1-da and 2-da sampling with moist terrain during 2-da sampling.

Trials 6 through 10: Average air temp 77°F; 1.30 in. rain between 1-hr and 1-da sampling with moist terrain during 1-da sampling; trace of ppt between 1-da and 2-da sampling.

V. (C) DISCUSSION.

By definition*, persistency is "an expression of the duration of effectiveness of a war gas which is dependent on physical and chemical properties of the gas, weather, methods of dissemination, and condition of terrain." Therefore, the results presented in this report must be interpreted in terms of effectiveness, rather than in consideration of whether or not the presence of residual agent in the ground remains detectable by chemical analysis of soil extractions. Thus, despite the presence of detectable quantities of active agent in the top 1/2-inch layer of terrain for weeks after the dispersion of V-agent, the persistency of the agent as determined by animal exposure and surface sampling is effectively only a matter of days.

If animal data can be assumed indicative of occupational hazard (ie, hazard incident to sitting or lying down in the area for several hours without benefit of protective equipment), the duration of such hazard could be expected from less than one day to several days, depending upon the density of contamination. For densities below 2.5 g/sq m, no appreciable number of fatalities might be expected to result from percutaneous effects suffered by troops entering and occupying the area in somewhat less than 24 hours following contamination. For high densities (10 to 30 g/sq m), the area might be safe for occupation sometime after two days, but less than a week following contamination. The results of animal exposure also indicate that the persistence of V-agent in dry sand is greater than in soil or grass sod. This fact almost appears to be a paradox in light of "soil-plug" results which indicate that residual agent can be extracted from the top 1/2-in. layer of soil for a longer period of time than from the top 1/2-in. layer of sand. This condition can be attributed to differences in physical properties of the two media.

The pick-up of agent on blotting-type surface samplers supported animal data by revealing the rapidity with which transferable surface contamination declined. The average quantities of agent available for transfer to surface samplers one hour and one day after the dissemination of VX were approximately 20% and 1% of the initial contamination density, respectively. This fact was corroborated in CWL Technical Memorandum 33-19, dated 10 February 1959, covering Phase B (Pick-Up) of the CWL Traversal Program. In that memorandum it was estimated that for terrain with a moderately-dense covering of short grass, troops crawling over the area one hour after the dissemination of agent would pick up about 20 times as much agent as would troops traversing the area one day later.

Surface-sampler data also provided a basis for estimating the duration of effectiveness of the disseminated agent to serve as a traversal hazard to personnel walking across contaminated areas. Since the pad of the sampler was pressed against the surface at the same pressure as that exerted by the sole of

*TM 3-215, Military Chemistry and Chemical Agents, August 1956.

a man's shoe when all his weight is on one foot as in walking, and since the pad is more absorbent than a shoe, the quantity of agent picked up per unit area of the pad should be in excess of that which could be picked up on the shoe. However, even if it were assumed that the pick-up on the pad represented the maximum quantity of agent that could be picked up on the shoe with each step, the hazard due to agent penetrating the footwear of personnel traversing contaminated areas with no or low vegetation (ie, 0 to 4-in. grass) would be nil or of very short duration. This assumption was predicated on a rough estimate which indicated that the maximum quantity of agent that could be picked up on each shoe of troops walking across 100 meters of terrain is numerically equal to 1-1/2 times the residual contamination density as determined by the surface samplers, or about 30% and 1-1/2% of the initial contamination density when the traversal is effected one hour and one day, respectively, after the dissemination of the contaminant. Thus, for example, if agent were deposited in a density of 1 g/sq m, the maximum pick-up might be 0.3 g on each shoe of troops walking across 100 meters of contaminated terrain within an hour after the dispersion of agent, and only 0.015 g when such traversal is effected one day later. These estimated quantities were based on the added facts that (1) each shoe contacts the ground 75 times in the 100-meter traversal, (2) the contact area of the shoe is about 0.02 sq m, and (3) the average quantities of agent transferable to surface samplers one hour and one day after the dispersion of V-agent are, as indicated above, about 20% and 1% of the initial contamination density, respectively. (NOTE: The effects of toxic vapors emanating from contaminated terrain were omitted from this discussion of traversal hazard. The evaporation rate and dosage production of VX from contaminated terrain is the subject of a special study currently in progress.)

ACKNOWLEDGMENT

The author wishes to express his appreciation and gratefully acknowledge the efforts of Mr. Albert Deiner, Chemical Test Branch, Test Division, in directing both the field and laboratory work associated with this phase of the CWL Traversal Program.

APPENDIX A

TABULATED DATA

TABLE 1

CONTAMINATION OF SOIL

Date	Days After Contamination	Residual Contamination Density	Rabbit Mortality	Av. Residual Cholinesterase in Survivors	Dose Indicated	Meteorological Conditions Ground Temp.	Av. Air Temp.	Rainfall
1957		g/sq.m.	Deaths/exposed	%	g/sq.m.	°F	°F	in.
3/12	0(1 Hr)	0.93	1/2	x	0.06	41		
3/13	[illegible]	2.11	0/2	85	-	66		
3/14	2	1.1[illegible]						
3/15	[illegible]	1.[illegible]					50-55	
3/18	[illegible]							[illegible]
3/19	[illegible]	[illegible]	[illegible]	[illegible]	-			[illegible]
3/21	[illegible]	[illegible]						0.1
3/26	[illegible]	0.1[illegible]					45-50	0.1
3/12		0.74	0/2	-	-	41		
3/13	1	0.59	0/2	100	-	[illegible]		
3/14	2	0.63					50-55	
3/15	3	0.[illegible]						
3/18	[illegible]							[illegible]
3/19	[illegible]	0.[illegible]						[illegible]
3/21	9	0.[illegible]						[illegible]
3/26	14	[illegible]					45-50	0.1
3/18	0	2.8[illegible]	2/2	-	0.2[illegible]	41		0.2
3/19	1	4.00	2/2	-	0.03[illegible]	38		0.1
3/20	2	3.0[illegible]						
3/21	3	3.1[illegible]						
3/22	4	2.8[illegible]						
3/25	7	2.[illegible]	1/2	20	0.03[illegible]	41		
3/26	8							0.1
3/28	10	1.[illegible]					45-50	
3/29	11							0.1
4/1	14	2.85	0/2	50	-	35		0.9
4/4	17							0.3
4/5	18							0.2
4/8	21	0.14						0.3
4/10	23	0.03						
3/18	0	3.79	2/2	-	0.23	41		0.2
3/19	1	2.66	1/2	50	0.017	38		0.1
3/20	2	1.57						
3/21	3	1.95						
3/22	4	2.40						
3/25	7	0.55	0/2	80	-	41	45-50	
3/26	8							0.1
3/28	10	0.81						
3/29	11							0.1
4/1	14	0.79	0/2	100	-	35		0.9
4/4	17							0.3
4/5	18							0.2
4/8	21	0.33						0.3
3/18	0	3.87	2/2	-	0.15	41		0.2
3/19	1	[illegible]	2/2	-	0.293	38		0.1
3/20	2	9.[illegible]						
3/21	3	12.5[illegible]						
3/22	4	6.18						
3/25	7	4.18	1/2	90	0.008	41		
3/26	8						45-50	0.1
3/28	10	4.03						
3/29	11							0.1
4/1	14	3.96	0/2	40	-	35		0.9
4/4	17							0.3
4/5	18							0.2
4/8	21	1.96						0.3
4/3	0	0.84						0.3
4/4	1	0.20						0.2
4/5-5/18	2-45						45-70	1.7
5/20	47	0.07						
4/22	0	1.14	2/2	-	0.74	75		
4/23	1	2.84	0/2	x	-	75	65-70	
4/29	7		0/2	95	-	78		
4/30	8	0.29						
5/6	14						55-60	0.1
5/7	15	0.51						
5/13	21	0.38						0.1
5/14	22							0.1
5/18	26						65-70	[illegible]
5/20	[illegible]	[illegible]						
5/25	[illegible]							0.3
5/29	[illegible]	0.[illegible]						
4/30	[illegible]	0.41	[illegible]	-	[illegible]	-		
5/1	1	[illegible]	[illegible]		-	-	[illegible]	
5/[illegible]								.1

5/[illegible]	[illegible]							
5/[illegible]								
5/[illegible]								
5/[illegible]		.						
5/[illegible]								
5/[illegible]		.						
[illegible]		[illegible]	[illegible]	-	[illegible]	-		
5/[illegible]		[illegible]	[illegible]	[illegible]	-	-		
5/[illegible]								[illegible]
5/[illegible]		[illegible]	[illegible]	[illegible]	-	[illegible]		
5/[illegible]	1[illegible]	[illegible]						[illegible]
5/14	[illegible]						[illegible]	[illegible]
5/18	[illegible]							1.[illegible]
5/20		.0[illegible]						
5/6		.[illegible]	[illegible]	-	-	6[illegible]		[illegible]
5/7	1	[illegible]	[illegible]	75	-	[illegible]		
5/13	7	[illegible]	0/2	6[illegible]	-	3		[illegible]
5/14	[illegible]						[illegible]-70	[illegible].1
5/18	1[illegible]							1.[illegible]
5/20	[illegible]	0.1[illegible]						
5/25	1[illegible]							[illegible].3
5/29	[illegible]	[illegible].0[illegible]						
5/14	0	0.20	1/2	20	-	-		[illegible]
5/15	1	0.[illegible]	[illegible]/2	[illegible]	-	-		
5/18	4						[illegible]-70	1.[illegible]
5/20	7	0.11	0/2	100	-	-		
5-6/6	11-25							[illegible]
6/24	41	0.23						[illegible]
5-7/27	6?-74							[illegible]
7/29	76	0.06					75-80	
8/3	81							0.6
8/7	85	0.01						
5/14	0	0.20	0/2	20	-	-		0.1
5/15	1	[illegible]	0/2	65	-	-		
5/18	4							1.0
5/21	7	0.07	0/2	85	-	-		
5/25	11							0.3
5/29	15	.006					65-70	
6/2	19							0.6
6/5	22							1.3
6/8	25							0.[illegible]
6/24	41	0.13						
5/4	0	1.3[illegible]	2/2	-	0.08	-		
5/5	1	1.55	0/2	30	-	-	65-70	1.3
5/8	4							0.2
5/11	7	0.07	0/2	100	-	90		
5/17	13	0.11						
5/24	20	0.13					80	
5/25	21							0.8
5/29	25							0.6
6/8	34							0.6
6/22	48	0						
6/23	49							0.3
6/27	53						75-80	0.1
6/29	55	0.07						
7/3	60							0.6
7/7	64	0.04						
/10	0	3.3[illegible]	[illegible]/2	-	0.11	81		
/11	1	3.33	[illegible]/2	80	-	90		
/17	7	1.[illegible]	[illegible]/2	40	-	90	80	
/25	15	0.1[illegible]						0.8
/29	1[illegible]							0.[illegible]
/8	2[illegible]							0.6
/22	4[illegible]	0.04						
/23	4[illegible]							0.3
/27	47						75-80	0.1
/29	4[illegible]	0.15						0.6
/3	[illegible]							
/7	58	0.05						
/10	0	4.[illegible]	2/2	-	.	[illegible]1		
/11	1	3.78	0/2	80	-	90		
/17	7	0.53	[illegible]/2	90	-	[illegible]	80	
/25	15	0.15						0.8
/29	1[illegible]							0.[illegible]
/8	[illegible]							0.6
/22	[illegible]	0.15						0.3
/23	43						75-80	0.1
/27	4[illegible]							
/29	[illegible]	0.29						0.[illegible]
/3	54							
/7	[illegible]	0.10						
/24	0	[illegible]	[illegible]/2	-	0.27	96	80	0.[illegible]
/25	1	0.27	[illegible]/2	85	-	[illegible]8		
/27	3	0.33						0.[illegible]
/2[illegible]	[illegible]							
/1	7	0.26						0.6
/8	14	0.17						
/11	17	0.13						

/24	0	17.0	3/2	-	0.32	96		
/25	1	14.0	1/2	75	-	95		0.3
/27	3	0.31					80	
/29	5							0.6
/1	7	0.18						
/8	14	0.05						0.6
/11	17	0.09						
/16	22	0.11					75-30	
/22	28	0						
/23	29							0.3
/27	33							0.1
/29	35	0.08						
/3	40							0.6
/7	44	0.19						
/2	0	6.85	2/2	-	0.23	88		
/3	1	3.85	0/2	55	-	88		
/8	6	0.80						0.6
/9	7	0.80	0/2	85	-	96		
/16	14	0.09					75-30	
/22	20	0.07						
/23	21							0.3
/27	25							0.1
/29	27	0.03						
/3	32							0.6
/7	36	0.06						
/2	0	3.85	2/2	-	0.14	88		
/3	1	3.73	0/2	85	-	88		
/8	6	0.89						0.6
/9	7	0.12	0/2	85	-	96		
/16	14	0.0						
/22	20	0.13					75-80	
/23	21							0.3
/27	25							0.1
/29	27	0.02						
/3	32							0.6
/7	36	0.04						
/9	0	1.22	1/2	30	-	96		
/10	1	0.73	1/2	65	-	87		
/11	2	0.19						
/16	7	0.09	2/2	-	-	99		
/22	13	0.11						
/23	14						80	0.3
/27	18							0.1
/29	20	0.08						
/3	25							0.6
/7	29	0						
/9	0	0.63	2/2	-	-	96		
/10	1	0.3	0/2	100	-	87		
/11	2	0.08						
/16	7	0	1/2	80	-	99		
/22	13	0					80	
/23	14							0.3
/27	18							0.1
/29	20	0						
/9	0	0.61	2/2	65	-	96		
/10	1	0.58	0/2	100	-	87		
/11	2	0.18						
/16	7	0.10	2/2	-	-	99		
/22	13	0					80	
/23	14							0.3
/27	18							0.1
/29	20	0.05						
/3	25							0.6
/7	29	0.06						

3

[illegible] A

[illegible] 1

[illegible]

General	Date	Days After Contamination	Residual Contamination Density	Rabbit Mortality	Av. [illegible] (%)	[illegible] Initial
	1957		g/sq.m.	[illegible]	%	g/sq.m.
Initial Contamination: [illegible] g/sq.m.	3/1[illegible]	0 (1 hr)	[illegible]	1/2	x	[illegible]
Particle Size: [illegible]	3/1[illegible]	1	.11	[illegible]	[illegible]	-
Disperser: Microburette	3/1[illegible]	2	1.[illegible]			
Shaded Plot	3/15	3	[illegible]			
	3/1[illegible]	[illegible]				
	3/19	7	[illegible]	[illegible]	[illegible]	-
	3/2[illegible]	[illegible]	[illegible]			
	3/2[illegible]	1[illegible]	[illegible]			
Initial Contamination: 0.4g./sq.m.	3/12	0	0.[illegible]	[illegible]	-	-
Particle Size: 750µ	3/13	1	0.[illegible]	0/[illegible]	100	-
Disperser: Microburette	3/14	2	0.63			
Shaded Plot	3/15	3	0.[illegible]			
	3/16	[illegible]				
	3/1[illegible]	[illegible]	0.[illegible]			
	3/22	9	0.[illegible]			
	3/26	1[illegible]	[illegible]			
Initial Contamination: 20.0 g./sq.m.	3/18	0	[illegible]	[illegible]	-	[illegible]
Particle Size: 3,250 µ	3/19	1	[illegible]	[illegible]	-	[illegible]
Disperser: Macroburette	3/20	2	[illegible]			
Shaded Plot	3/21	3	[illegible]			
	3/22	4	[illegible]			
	3/25	7	[illegible]	1/[illegible]	[illegible]	0.[illegible]
	3/26	8				
	3/28	10	[illegible]			
	3/29	11				
	4/1	14	2.[illegible]	0/[illegible]	[illegible]	-
	4/4	17				
	4/5	18				
	4/8	21	0.14			
	4/10	23	0.03			
Initial Contamination: 20.0 g./sq.m.	3/18	0	3.79	[illegible]	-	0.23
Particle Size: 3,400µ	3/19	1	2.66	1/2	50	0.01[illegible]
Disperser: Macroburette	3/20	2	1.87			
Shaded Plot	3/21	3	1.95			
	3/22	4	2.40			
	3/25	7	0.[illegible]	0/2	60	-
	3/26	8				
	3/28	10	0.81			
	3/29	11				
	4/1	14	0.79	0/2	100	-
	4/4	17				
	4/5	18				
	4/8	21	0.[illegible]			
Initial Contamination: 31.5 g./sq.m.	3/18	0	3.[illegible]	2/2	-	0.15
Particle Size: 3,480µ	3/19	1	[illegible].98	2/2	-	0.29[illegible]
Disperser: Macroburette	3/20	2	9.90			
Shaded Plot	3/21	3	12.5[illegible]			
	3/22	4	6.48			
	3/25	7	4.48	1/2	90	0.00[illegible]
	3/26	8				
	3/28	10	4.03			
	3/29	11				
	4/1	14	3.96	0/2	40	-
	4/4	17				
	4/5	18				
	4/8	21	1.96			
Initial Contamination: 0.5 g./sq.m.	4/3	0	0.84			
Particle Size: 750µ	4/4	1	0.20			
Disperser: Spinning Tip	4/5-5/18	2-45				
Shaded Plot	5/20	47	0.07			
Initial Contamination: 1.8 g./sq.m.	4/22	0	1.14	[illegible]/2	-	0.7[illegible]
Particle Size: <200µ	4/23	1	1.94	0/2	x	-
Disperser: Spinning Tip	4/2[illegible]	[illegible]		0/2	[illegible]5	-
Shaded Plot	4/30	8	0.2[illegible]			
	5/[illegible]	1[illegible]				
	5/7	15	0.51			
	5/1[illegible]	21	0.38			
	5/14	2[illegible]				
	5/15	26				
	5/20	[illegible]	[illegible]			
	5/2[illegible]	3[illegible]				
	5/29	37	[illegible]			
Initial Contamination: [illegible] g./sq.m.	4/30	0	0.31	[illegible]	-	.[illegible]
Particle Size: <20 µ	5/1	1	0.11	[illegible]	[illegible]	-
Disperser: Spinning Tip	5/6	[illegible]				
Shaded Plot	5/7	7	[illegible]	[illegible]/2	1[illegible]	-
	5/1[illegible]	[illegible]	[illegible]			
	5/[illegible]	1[illegible]				

Initial Contamination: 0.3 g./sq.m. Particle Size: 4200μ Disperser: Spinning Tip Shaded Plot	5/14	0	0.20	1/2	50	-
	5/15	1	0.11	0/2	0	-
	5/18	4				
	5/21	7	.11	1/2	50	-
	5/25-6/27	11-34				
	6/24	31	0.13			
	7/27	76	0.00			
	8/3	81				
	8/7	85	0.01			
Initial Contamination: 0.3 g./sq.m. Particle Size: 4200μ Disperser: Spinning Tip Shaded Plot	5/14	0	0.20	0/2	50	-
	5/15	1	0.11	0/2	0	-
	5/18	4				
	5/21	7	0.07	0/2	0	-
	5/25	11				
	5/29	15	.008			
	6/2	19				
	6/5	22				
	6/8	25				
	6/24	41	0.13			
Initial Contamination: 1.7 g./sq.m. Particle Size: 470μ Disperser: Spinning Tip Shaded Plot	6/4	0	1.33	2/2	-	0.08
	6/5	1	1.25	0/2	0	-
	6/8	4				
	6/11	7	0.07	0/2	0	-
	6/17	13	0.11			
	6/24	20	0.13			
	6/25	21				
	6/29	25				
	7/8	34				
	7/22	48	0			
	7/23	49				
	7/27	53				
	7/29	55	0.07			
	8/3	60				
	8/7	64	0.04			
Initial Contamination: 1.0 g./sq.m. Particle Size: 220μ Disperser: Spinning Tip Shaded Plot	6/10	0	3.32	1/2	-	0.11
	6/11	1	3.33	0/2	0	-
	6/17	7	1.06	0/2	0	-
	6/25	15	0.13			
	6/29	19				
	7/8	28				
	7/22	42	0.04			
	7/23	43				
	7/27	47				
	7/29	49	0.15			
	8/3	54				
	8/7	58	0.05			
Initial Contamination: 0.9 g./sq.m. Particle Size: 230μ Disperser: Spinning Tip Shaded Plot	6/10	0	2.91	2/2	-	0.11
	6/11	1	3.78	0/2	0	-
	6/17	7	0.53	0/2	0	-
	6/25	15	0.15			
	6/29	19				
	7/8	28				
	7/22	42	0.15			
	7/23	43				
	7/27	47				
	7/29	49	0.19			
	8/3	54				
	8/7	58	0.10			
Initial Contamination: 20.0 g./sq.m. Particle Size: 3,700μ Disperser: Macroburette	6/24	0	31.8	2/2	-	0.27
	6/25	1	7.37	0/2	0	-
	6/27	3	0.81			
	6/29	5				
	7/1	7	0.76			
	7/8	14	0.19			
	7/11	17	0.13			
	7/16	22	0.06			
	7/22	28	0.13			

Initial Contamination: [illegible] g./sq.m.	[illegible]	0	[illegible]		-	[illegible]
Particle Size: [illegible]	[illegible]	1	[illegible]	[illegible]		
Disperser: Macroburette	[illegible]	[illegible]	[illegible]			
	[illegible]	5				
	7/1	7	[illegible]			
	[illegible]	[illegible]				
	7/11	[illegible]	[illegible]			
	7/16	[illegible]	[illegible]			
	7/22	[illegible]				
	[illegible]	[illegible]				
	[illegible]	[illegible]				
	[illegible]	[illegible]	[illegible]			
	[illegible]	[illegible]				
	8/7	44	[illegible]			
Initial Contamination: [illegible]0.0 g./sq.m.	6/24	0	[illegible]7.0	2/2	-	[illegible]
Particle Size: 4,140 μ	6/25	1	[illegible].0	1/2		-
Disperser: Macroburette	6/27	3	0.41			
	6/29	[illegible]				
	7/1	7	0.14			
	7/6	12	0.05			
	7/11	17	0.09			
	7/16	22	0.11			
	7/22	28	0			
	7/23	29				
	7/27	33				
	7/29	35	0.05			
	8/3	40				
	8/7	44	0.19			
Initial Contamination: 4.8 g./sq.m.	7/2	0	6.45	2/2	-	[illegible]
Particle Size: 225 μ	7/3	1	3.85	0/2	55	-
Disperser: Spinning Tip	7/8	6	0.80			
	7/9	7	0.20	0/2	65	-
	7/16	14	0.09			
	7/22	20	0.07			
	7/23	21				
	7/27	25				
	7/29	27	0.03			
	8/3	32				
	8/7	36	0.06			
Initial Contamination: 3.5 g./sq.m.	7/2	0	3.85	2/2	-	0.14
Particle Size: 225 μ	7/3	1	2.73	0/2	85	-
Disperser: Spinning Tip	7/8	6	0.29			
	7/9	7	0.14	0/2	85	-
	7/16	14	0.09			
	7/22	20	0.13			
	7/23	21				
	7/27	25				
	7/29	27	0.02			
	8/3	32				
	8/7	36	0.04			
Initial Contamination: 2.9 g./sq.m.	7/9	0	1.22	1/2	30	-
Particle Size: 225 μ	7/10	1	0.73	1/2	65	-
Disperser: Spinning Tip	7/11	2	0.19			
	7/16	7	0.09	2/2	-	-
	7/22	13	0.11			
	7/23	14				
	7/27	18				
	7/29	20	0.08			
	8/3	25				
	8/7	29	0			
Initial Contamination: 1.6 g./sq.m.	7/9	0	0.63	2/2	-	-
Particle Size: 225 μ	[illegible]	1	0.34	0/2	100	-
Disperser: Spinning Tip	7/11	2	0.04			
	7/16	7	0	1/2	60	-
	7/22	13	0			
	7/23	14				
	7/27	18				
	7/29	20	0			
Initial Contamination: 0.6 g./sq.m.	7/9	0	0.61	0/2	65	-
Particle Size: 225 μ	7/10	1	0.58	0/2	100	-
Disperser: Spinning Tip	7/11	2	0.18			
	7/16	7	0.10	2/2	-	-
	7/22	13	0			
	7/23	14				
	7/27	18				
	7/29	20	0.05			
	8/3	25				
	8/7	29	0.06			

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CON[illegible]

APPENDIX A

TABLE 2

CONTAMINATION OF SAND

General	Date	Days After Contamination	Residual Contamination Density	Rabbit Mortality	Av. Residual Cholinesterase in Survivors	Dose Indicated	Meteorological Condition Ground Temp.	Av. Air Temp.	Rainfall
	1957		g./sq.m.	Deaths/Exposed	%	g./sq.m.	°F	°F	in.
Initial Contamination: 20.0g./sq.m. Particle Size: 3,600µ Disperser: Macroburette	8/27	0	29.5	2/2	-	0.20	85		
	8/28	1	16.7	2/2	-	0.09	83		
	8/29	2	4.4						
	8/30	3	1.2						
	9/3	7	0.8	0/2	80	-	84	70-75	
	9/7	11							0.3
	9/9	13							0.2
	9/10	14							2.5
	9/11	15	0.01						
Initial Contamination: 20.0g./sq.m. Particle Size: 3,800µ Dispersers: Macroburette Shaded plot	8/27	0	28.4	2/2	-	0.70	85		
	8/28	1	21.6	2/2	-	0.04	83		
	8/29	2	7.5						
	8/30	3	6.1						
	9/3	7	0.9	0/2	35	-	84	70-75	
	9/7	11							0.3
	9/9	13							0.2
	9/10	14							2.5
	9/11	15	0.2						
Initial Contamination: 20.0g./sq.m. Particle Size: 3,600µ Disperser: Macroburette	8/27	0	26.7	2/2	-	0.08	85		
	8/28	1	11.7	2/2	-	0.13	83		
	8/29	2	9.2						
	8/30	3	0.14						
	9/3	7	0.35	0/2	90	-	84	70-75	
	9/7	11							0.3
	9/9	13							0.2
	9/10	14							2.5
	9/11	15	0						
Initial Contamination: 20.0g./sq.m. Particle Size: 3,500µ Dispersers: Macroburette Shaded plot	8/27	0	4.9	2/2	-	0.39	85		
	8/28	1	3.1	2/2	-	0.06	83		
	8/29	2	5.2						
	8/30	3	3.9						
	9/3	7	0.05	0/2	45	-	84	70-75	
	9/7	11							0.3
	9/9	13							0.2
	9/10	14							2.5
	9/11	15	0.17						
Initial Contamination: 11.9g./sq.m. Particle Size: 275µ Disperser: Spinning Tip.	9/18	0	3.0	2/2	-	0.42	77		
	9/19	1	0.25	2/2	-	0.15	79		
	9/20	2	5.1						
	9/21	3							0.1
	9/23	5	0.35						
	9/24	6	0.41						
	9/25	7	0.18	0/2	90	-	69	50-65	

	9/11	15	0						2.5
Initial Contamination: 20.0g./sq.m. Particle Size: 3,500µ Disperser: Macroturette Shaded plot	8/27	0	4.9	2/2	-	0.39	85		
	8/28	1	3.1	2/2	-	0.06	83		
	8/29	2	5.2						
	8/30	3	3.9						
	9/3	7	0.05	0/2	45	-	84	70-75	
	9/7	11							0.3
	9/9	13							0.2
	9/10	14							2.5
	9/11	15	0.17						
Initial Contamination: 11.9g./sq.m. Particle Size: 225µ Disperser: Spinning Tip.	9/18	0	3.0	2/2	-	0.42	77		
	9/19	1	0.25	2/2	-	0.15	79		
	9/20	2	5.1					75	
	9/21	3							0.1
	9/23	5	0.35						
	9/24	6	0.41					50-65	
	9/25	7	0.18	0/2	90	-	69		
	10/2	14	0						
Initial Contamination: 9.1g./sq.m. Particle Size: 225µ Disperser: Spinning Tip. Shaded plot	9/18	0	2.6	2/2	-	0.22	77		
	9/19	1	1.3	2/2	-	0.11	79	75	
	9/20	2	3.9						
	9/21	3							0.1
	9/23	5	0.40						
	9/24	6	0.22					50-65	
	9/25	7	0.08	0/2	50	-	69		
	10/2	14	0						
Initial Contamination: 13.9g./sq.m. Particle Size: 400µ Disperser: Spinning Tip.	9/23	0	5.9	2/2	-	1.32	70		
	9/24	1	3.8	2/2	-	0.13	76		
	9/25	2	0.8						
	9/26	3	0.9						
	9/27	4	0.3					50-60	
	9/30	7	0.08	0/2	55	-	66		
	10/6	13							0.8
	10/7	14							0.2
	10/8	15	0.05						0.1
Initial Contamination: 6.5g./sq.m. Particle Size: 400µ Disperser: Spinning Tip. Shaded plot	9/23	0	2.3	2/2	-	0.36	70		
	9/24	1	0.98	2/2	-	0.20	76		
	9/25	2	0.30						
	9/26	3	0.12						
	9/27	4	0.12					50-60	
	9/30	7	0.02	0/2	20	0	66		
	10/6	13							0.8
	10/7	14							0.2
	10/8	15	0.05						0.1

2

CONFIDENTIAL

APPENDIX A

TABLE 3

CONTAMINATION OF GRASS SOD

General	Date	Days After Contamination	Residual Contamination Density	Rabbit Mortality	Av. Residual Cholinesterase in Survivors	Dose Indicated	Meteorological Condition Ground Temp.	Av. Air Temp.	Rainfall
	1958		g./sq.m.	Deaths/Exposed	%	g./sq.m.	°F	°F	in.
Initial Contamination: 4.9g./sq.m.	1/7	0	1.94	2/2	--	0.36	35		0.5
Particle Size: 300μ MMD	1/8	1	1.67	2/2	--	0.20	27		
Dispersers: Spinning Tip	1/9	2	1.06				28		
	1/10	3	0.51				33		
	1/14	7	0.35				39	25-35	1.4
	1/15	8		0/2	90	----	44		0.5
	1/21	14	0.14				36		0.2
Initial Contamination: 0.4 g./sq.m.	1/21	0	0.12	0/2	65	----	36		0.2
Particle Size: 380μ MMD	1/22	1	0.03	1/2	65	----	43	35	0.6
Dispersers: Spinning Tip.	1/23	2	0.02				31		
Initial Contamination: 0.3g./sq.m.	1/21	0	0.06	1/2	30	----	36		0.2
Particle Size: 395μ MMD	1/22	1	0.01	1/2	100	----	43	35	0.6
Dispersers: Spinning Tip.	1/23	2	0.01				31		
Initial Contamination: 11.3g./sq.m.	6/3	0	2.30	1/2	--	0.13	70		
Particle Size: 250μ MMD	6/4	1	.06	0/2	25	----	87		
Dispersers: Spinning Tip.	6/5	2	.04					65	
	6/6	3	.03	0/2	--	----	80		
Initial Contamination: 7.5 g./sq.m.	6/3	0	1.37	2/2	--	0.12	70		
Particle Size: 250μ MMD	6/4	1	0.07	1/2	30	0.02	87		
Dispersers: Spinning Tip.	6/5	2	0.06					65	
	6/6	3	0.03	0/2	--	----	80		
Initial Contamination: 3.5g./sq.m.	6/16	0	0.40	1/2	20	----	70		
Particle Size: 185μ MMD	6/17	1	0.01	0/2	45	----	82	65	
Dispersers: Spinning Tip.	6/18	2	0.01						
Initial Contamination: 2.2g./sq.m.	6/16	0	0.29	0/2	25	----	70		
Particle Size: 260μ MMD	6/17	1	0.02	0/2	30	----	83	65	
Dispersers: Spinning Tip.	6/18	2	0.002						
Initial Contamination: 12.6g./sq.m.	6/30	0	2.25	2/2	--	1.43	90		
Particle Size: 450μ MMD	7/1	1	0.15	2/2	--	0.41	95		
Dispersers: Spinning Tip.	7/2	2	0.10	1/2	75	0.21	97	80	
	7/3	3	0.09	2/2	--	0.18	100		
Initial Contamination: 17.2g./sq.m.	6/30	0	2.17	2/2	--	0.39	90		
Particle Size: 185μ MMD	7/1	1	0.19	2/2	--	0.06	95		
Dispersers: Spinning Tip.	7/2	2	0.17	1/2	70	0.12	97	80	
	7/3	3	0.08	2/2	--	0.30	100		

General	Date	Days After Contamination	Residual Contamination Density	Rabbit Mortality	Av. Residual Cholinesterase in Survivors	Dose Indicated	Meteorological Condition Ground Temp.	Av. Air Temp.	Rainfall
	1958		g./sq.m.	Deaths/Exposed	%	g./sq.m.	°F	°F	in.
Initial Contamination: 4.2g./sq.m. Particle Size: 300μ MMD Disperser: Spinning Tip	1/7	0	1.94	2/2	--	0.36	35		0.5
	1/8	1	1.67	2/2	--	0.20	27		
	1/9	2	1.06				28		
	1/10	3	0.51				33		
	1/14	7	0.35				39	25-35	1.4
	1/15	8		0/2	90	----	44		0.5
	1/21	14	0.14				36		0.2
Initial Contamination: 0.4 g./sq.m. Particle Size: 380μ MMD Disperser: Spinning Tip.	1/21	0	0.12	0/2	65	----	36		0.2
	1/22	1	0.03	1/2	65	----	43	35	0.6
	1/23	2	0.02				31		
Initial Contamination: 0.3g./sq.m. Particle Size: 395μ MMD Disperser: Spinning Tip.	1/21	0	0.06	1/2	30	----	36		0.2
	1/22	1	0.01	1/2	100	----	43	35	0.6
	1/23	2	0.01				31		
Initial Contamination: 11.3g./sq.m. Particle Size: 250μ MMD Disperser: Spinning Tip.	6/3	0	2.39	1/2	--	0.13	70		
	6/4	1	.06	0/2	25	----	87		
	6/5	2	.04					65	
	6/6	3	.03	0/2	--	----	80		
Initial Contamination: 7.5 g./sq.m. Particle Size: 250μ MMD Disperser: Spinning Tip.	6/3	0	1.37	2/2	--	0.12	70		
	6/4	1	0.07	1/2	30	0.02	87		
	6/5	2	0.06					65	
	6/6	3	0.03	0/2	--	----	80		
Initial Contamination: 3.5g./sq.m. Particle Size: 185μ MMD Disperser: Spinning Tip.	6/16	0	0.40	1/2	20	----	70		
	6/17	1	0.01	0/2	45	----	83	65	
	6/18	2	0.01						
Initial Contamination: 2.2g./sq.m. Particle Size: 260μ MMD Disperser: Spinning Tip.	6/16	0	0.29	0/2	25	----	70		
	6/17	1	0.01	0/2	30	----	83	65	
	6/18	2	0.002						
Initial Contamination: 12.6g./sq.m. Particle Size: 450μ MMD Disperser: Spinning Tip.	6/30	0	2.25	2/2	--	1.43	90		
	7/1	1	0.15	2/2	--	0.41	95		
	7/2	2	0.10	1/2	75	0.21	97	80	
	7/3	3	0.09	2/2	--	0.18	100		
Initial Contamination: 17.2g./sq.m. Particle Size: 185μ MMD Disperser: Spinning Tip.	6/30	0	2.17	2/2	--	0.39	90		
	7/1	1	0.19	2/2	--	0.06	95		
	7/2	2	0.17	1/2	70	0.12	97	80	
	7/3	3	0.08	2/2	--	0.30	100		

TABLE 4

SUMMARY OF SHORT MORTALITY DATA

Terrain	Trial Began	Initial Contamination Density g./sq.ft.	Mortality Fraction (No. Deaths/No. Exposed) and Time Till Death (min.) Resulting From 1-Hour Exposure to Contaminated Terrain at the Following Times After Ground Contamination									
			1 Hour		Intervening Rainfall (in.)	1 Day		Intervening Rainfall (in.)	1 Week		Intervening Rainfall (in.)	
			Mortality Fraction	Av. Time Till Death		Mortality Fraction	Av. Time Till Death		Mortality Fraction	Av. Time Till Death		
Soil	5/11/57	0.3	0/2	-	x	0/2	-	x	0/2	-		
	5/11/57	0.3	1/2	95	x	0/2	-	x	0/2	-		
	3/12/57	0.4	0/2	-	x	0/2	-	x	-	-		
	4/30/57	0.5	2/2	65	x	0/2	-	x	0/2	-		
	4/30/57	0.5	2/2	74	x	1/2	65	x	0/2	-		
	7/ 9/57	0.6	0/2#	-	0	0/2	-	0	2/2#	60		
	5/ 6/57	1.0	2/2	*	x	0/2	-	x	0/2	-		
	7/ 9/57	1.6	2/2	*	0	0/2	-	0	1/2	60		
	6/ 4/57	1.7	2/2	71	x	0/2	-	x	0/2	-		
	4/22/57	1.8	2/2	79	x	0/2	-	x	0/2	-		
	7/ 9/57	2.9	1/2	*	0	1/2	65	0	2/2#	*		
	7/ 2/57	3.5	2/2	53	0	0/2	-	0.6	0/2	-		
	3/12/57	4.0	1/2	90	x	0/2	-	x	0/2	-		
	6/10/57	4.6	2/2	61	x	0/2	-	x	0/2	-		
	7/ 2/57	4.8	2/2	28	0	0/2	-	0.6	0/2#	-		
	6/10/57	6.9	2/2	34	x	0/2	-	x	0/2	-		
	3/18/57	20.0	2/2	41	x	2/2	115	x	1/2	110		
	3/18/57	20.0	2/2	45	x	1/2	150	x	0/2	-		
	6/24/57	20.0	2/2#	39	0.8	0/2#	-	0.6	-	-		
	6/24/57	20.0	2/2#	48	0.8	0/2#	-	0.6	-	-		
	6/24/57	20.0	2/2#	36	0.8	1/2#	*	0.6	-	-		
	3/18/57	31.5	2/2	56	x	2/2	40	x	1/2	230		
Sand	9/23/57	6.5	2/2	42	x	2/2	*	x	0/2	-		
	9/18/57	9.1	2/2	44	x	2/2	*	x	0/2	-		
	9/18/57	11.0	2/2	41	0	2/2	61	0	0/2	-		
	9/23/57	13.9	2/2	18	0	2/2	57	0	0/2	-		
	8/27/57	20.0	2/2	25	0	2/2	98	0	0/2	-		
	8/27/57	20.0	2/2	38	x	2/2	84	x	0/2	-		
	8/27/57	20.0	2/2	44	0	2/2	71	0	0/2	-		
	8/27/57	20.0	2/2	71	x	2/2	72	x	0/2	-		
	1/21/58	0.3	1/2	*	0.2	1/2	*	0.6				
	1/21/58	0.4	0/2	-	0.2	1/2	*	0.6				
	1/ 7/58	4.9	2/2	36	0.5	2/2#	48	1.9	0/2	-		
									2 Days		3 Days	
Grass Sod	6/16/58	2.2	0/2	-	0	0/2	-					
	6/16/58	3.5	1/2	30	0	0/2	-					
	6/ 3/58	7.5	1/2	=	0	0/2	-	0			0 0/2	-
	6/ 3/58	11.3	2/2	*	0	1/2	*	0			0 0/2	-
	6/30/58	12.6	2/2	20	0	2/2#	45	0	1/2#	45	0 2/2#	47
	6/20/58	17.2	2/2	45	0	2/2#	*	0	1/2#	60	0 2/2#	48

REMARKS

The ground temperature was either $\leq 32°F.$ or $\geq 95°F.$ during animal exposure.

* Death occurred overnight.

x Test plots were shaded from sun and rain.

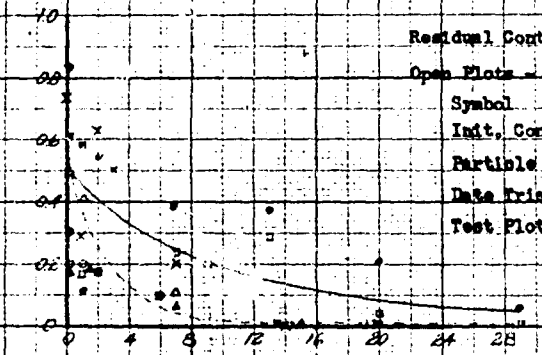
APPENDIX B

GRAPHS

CONTA[redacted]

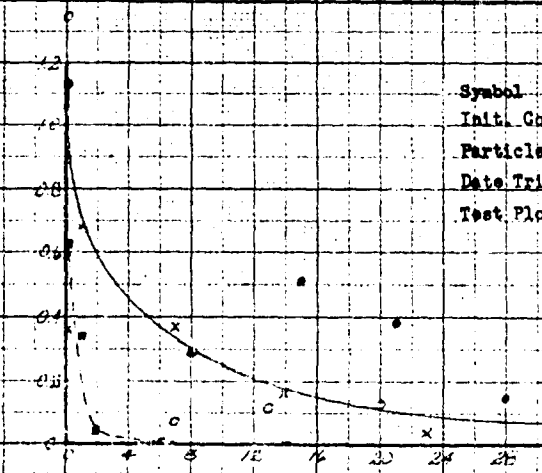
Residual Contamination Density ($g_r/sq.ft.$) Versus Time (days)

Open Plots - - - - - - Shaded Plots ———

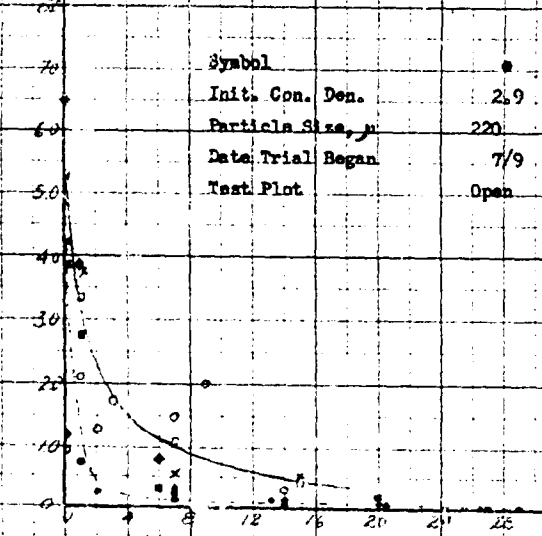


Symbol	△	▲	×	□
Init. Con. Den.	0.3	0.3	0.4	0.5
Particle Size, μ	<200	<200	780	750
Date Trial Began	5/14	5/14	3/12	4/3
Test Plot	Shaded	Shaded	Shaded	Shaded

Symbol	●	■	○	◆
Init. Con. Den.	0.5	0.5	0.6	
Particle Size, μ	750	220	225	
Date Trial Began	4/3	4/30	7/9	
Test Plot	Shaded	Shaded	Open	



Symbol	×	■	○	◆
Init. Con. Den.	1.0	1.6	1.7	1.8
Particle Size, μ	<200	225	470	200
Date Trial Began	5/6	7/9	6/4	4/22
Test Plot	Shaded	Open	Shaded	Shaded



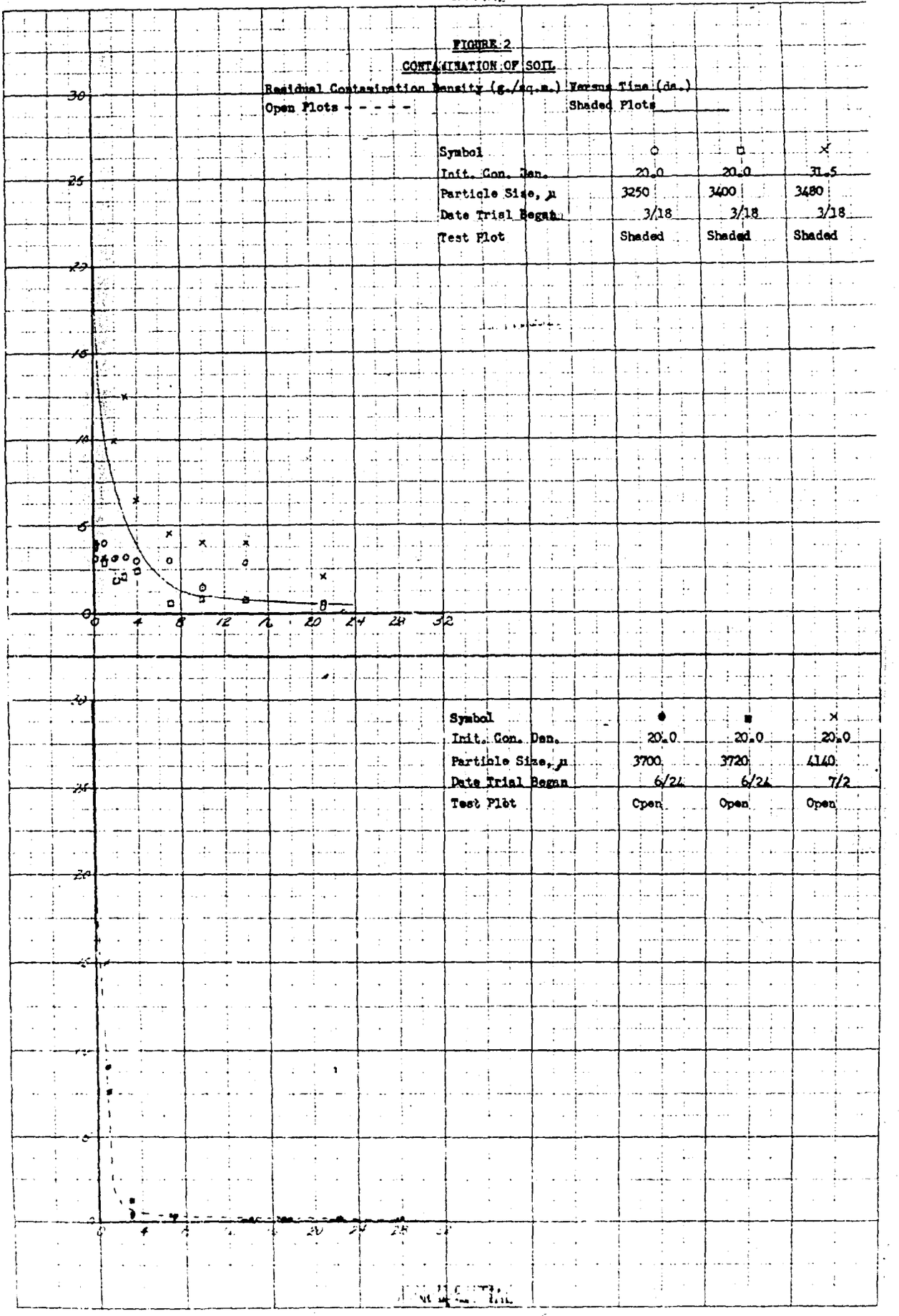
Symbol	●	■	○	□	◆	×
Init. Con. Den.	2.9	3.5	4.0	4.6	4.8	6.9
Particle Size, μ	220	225	1450	220	225	230
Date Trial Began	7/9	7/2	3/12	6/10	7/2	6/10
Test Plot	Open	Open	Shaded	Shaded	Open	Shaded

FIGURE 2

CONTAMINATION OF SOIL

Residual Contamination Density (g./sq.m.) Versus Time (da.)

Open Plots - - - - - Shaded Plots _____



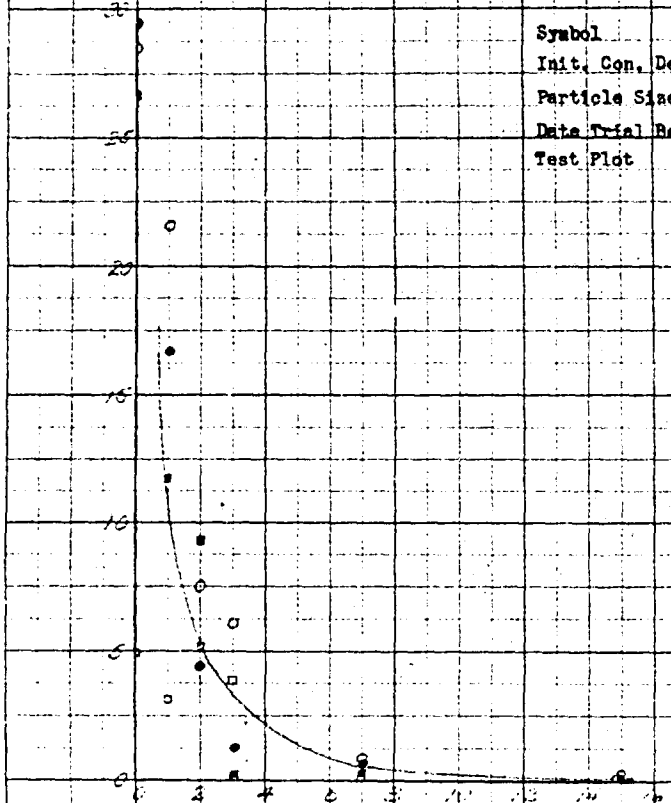
Symbol	○	□	×
Init. Con. Den.	20.0	20.0	31.5
Particle Size, μ	3250	3400	3480
Date Trial Began	3/18	3/18	3/18
Test Plot	Shaded	Shaded	Shaded

Symbol	●	■	×
Init. Con. Den.	20.0	20.0	20.0
Particle Size, μ	3700	3720	4140
Date Trial Began	6/24	6/24	7/2
Test Plot	Open	Open	Open

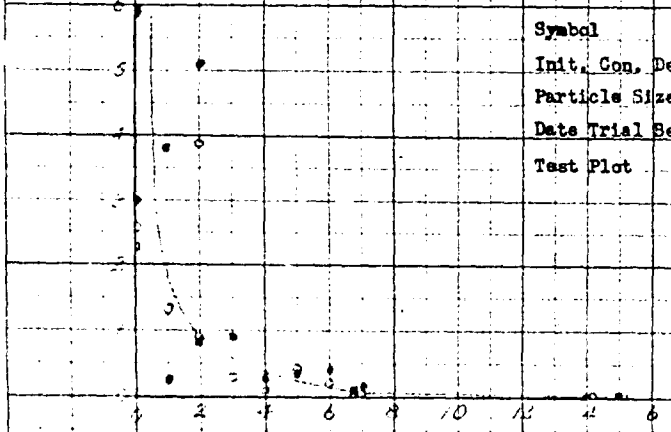
FIGURE 3

CONTAMINATION OF SAND

Residual Contamination Density (g./sq.m.) Versus Time (da.)



Symbol	●	○	■	□
Init. Con. Den.	20.0	20.0	20.0	20.0
Particle Size, μ	3600	3800	3600	3500
Date Trial Began	8/27	8/27	8/27	8/27
Test Plot	Open	Shaded	Open	Shaded



Symbol	◆	◆	□	○
Init. Con. Den.	11.9	13.9	6.5	9.1
Particle Size, μ	225	400	400	225
Date Trial Began	9/18	9/23	9/23	9/18
Test Plot	Open	Open	Shaded	Shaded

APPENDIX C

PHOTOGRAPHS

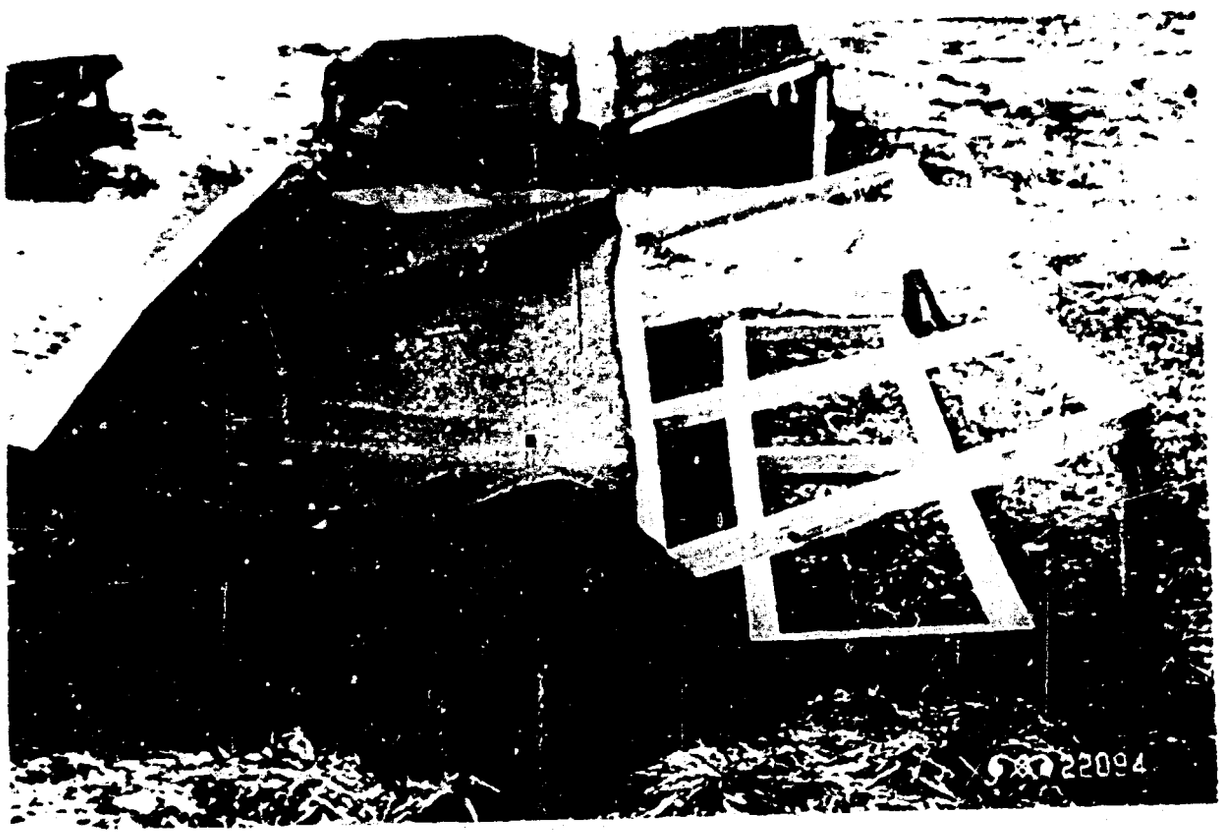


FIGURE 1

ARRANGEMENT OF TEST PLOTS

View shows wooden frames denoting test plots and the manner in which these plots were shaded from sun and rain. The covers were pitch towards drainage ditches for the run-off of rain water.

FIGURE 2

SPINNING TIP APPARATUS

View shows sled-mounted spinning tip apparatus being filled preparatory to disseminating agent in fine droplets.

APPENDIX D

REPORTS

Soil Survey Laboratory
Plant Industry Station
Beltsville, Maryland
February 7, 1958

Mr. Abraham Koblin
Test Division CWL
Army Chemical Center
Edgewood, Maryland

Dear Mr. Koblin:

Work has been completed on the two samples that you left with us.

The soil samples from the covered and uncovered plots are nearly identical with respect to particle size distribution and chemical properties. The clay content is low, averaging only 5.2%. However, the exchange capacity per unit clay is fairly high, averaging 150 meq/100 g clay. The percentage exchangeable sodium is high, averaging 23.1 percent. The conductivity measurements indicate the equivalent of approximately 3 meq/liter of NaCl in the saturation extract. Although this is not high enough to be considered a saline soil, this is higher than normal for soils of the area. The high sodium content is undoubtedly due to proximity of the site to Chesapeake Bay.

The clay contains vermiculite, illite, some mixed-layer mineral intermediate between illite and vermiculate, and traces of kaolin. No montmorillonite is present. There is also a component which gives a fairly strong exothermic reaction in Differential Thermal at 520° analyses, which has not been identified thus far.

Sincerely yours,

Lyle T. Alexander
Chief, Soil Survey Laboratory

Enclosure

DEPARTMENT OF THE ARMY
US ARMY RESEARCH, DEVELOPMENT AND ENGINEERING COMMAND
EDGEWOOD CHEMICAL BIOLOGICAL CENTER
5183 BLACKHAWK ROAD
ABERDEEN PROVING GROUND, MD 21010-5424

REPLY TO
ATTENTION OF

RDCB-DSR-S

JUL 1 1 2016

MEMORANDUM THRU Director, Edgewood Chemical Biological Center, (RDCB-D/ Dr. Joseph Corriveau), 5183 Blackhawk Road, Aberdeen Proving Ground, Maryland 21010-5424

FOR Defense Technical Information Center, 8725 John J. Kingman Road, Ft Belvoir, VA 22060

SUBJECT: Internal Request for Change in Distribution

1. This action is in response to an Edgewood Chemical Biological Center (ECBC) Internal Request for a Change in Distribution.

2. The attached listed documents have been reviewed by ECBC Subject Matter Experts and deemed suitable for the change in distribution to read "Approved for public release; distribution unlimited."

3. The point of contact is Adana Eilo, ECBC Security Specialist, (410) 436-2063 or adana.l.eilo.civ@mail.mil.

Encl

RONALD L. STAFFORD
Security Manager

1. Manthie, J.H., Heitkamp, D.H. Dorsey, R.W., Stark, W.C., Bona, D.M., Moore, R.D., and Cameron, K.P., *Mustard Contact Hazard, Correlation of Effects on Skin with Contamination Levels Recovered from Dental Dam and Painted Steel Surfaces*, CRDEC-TR-88142, August 1988 (Dist. B. - U. S. Government Agencies) **DTIC: CBRNIAC-CB-009397**

2. Manthei, J.H.; Heitkamp, D.H.; Dorsey, W.C.; Starke, W.C.; Braun, R.A.; Bona, D.M.; Moore, R.D.; Cameron, K.P.; Klein, J.M. *Toxic Hazard to the Rabbit from Direct and Vapor Contact with HD-Contaminated Plexiglas, Concrete, or XM40 Nylon Carrier Material*; CRDEC-TR-86072; U.S. Army Chemical Research, Development and Engineering Center: Aberdeen Proving Ground, MD, 1986 (Dist. B. - U. S. Government Agencies) **DTIC: ADB105323**

3. Manthei, J.H.; Heitkamp, W.C.; Starke, W.C.; Braun, R.A.; Bona, D.M.; Moore, R.D.; Cameron, K.P.; Heyl, W. C., *Toxicological Evaluation of the Contact and Vapor Hazards of VX and Thickened VX (TVX) in Rabbits*, CRDEC-TR-84072; U.S. Army Chemical Research, Development and Engineering Center: Aberdeen Proving Ground, MD, 1985 (Dist. B. - U. S. Government Agencies) **DTIC: ADB095637**

4. Reich, N., *Interim Report CWL Traversal Program Phase B – Pick-Up (Effects of Ground Moisture), CWL Technical Memorandum 33-26*, U.S. Army Chemical Warfare Laboratories, Army Chemical center, MD, June 1960 (Dist. C. - U. S. Government Agencies and their Contractors) **DTIC: AD0318492**

5. Reich, N. *Interim Report CWL Traversal Program Phase B – Pick Up, CWL Technical Memorandum 33-19*, U.S. Army Chemical Warfare Laboratories, Army Chemical Center, MD, February 1959 (Dist. C. - U. S. Government Agencies and their Contractors) **DTIC: AD 306322**

6. Reich, N. *Interim Report CWL Traversal Program Phase A – Persistence, CWL Technical Memorandum 33-18*, U.S. Army Chemical Warfare Laboratories, Army Chemical Center, MD, February 1959 (Dist. C. U. S. Government Agencies and their Contractors)
DTIC: CBRNIAC-CB-047279

7. Deseret Test Center. *Environmental impact statement for the study of the toxicity and fate of agent and residues in vegetation and soil*, DTC Test CT-1 and CT-2, Deseret Test Center, Fort Douglas, UT, 1970. (Dist. B. - U. S. Government Agencies) **DTIC: CBRNIAC-CB-104377**

8. Houle, M. D., Long, D. E., *Methodology Investigation Final report Repid Evaluation of Environmental Hazards: the fate of VX and GB in the Dugway Proving Ground Environment*, GPG Document No. DPG-FR-85-703U. S. Army Dugway Proving Ground, Dugway, UT, March 1989 (Dist. B. - U. S. Government Agencies) **DTIC: ADB131330**